STUDY MASS TRANSFER OF Cd, Hg, As, DDT AND CHLORDANE BY ADSORPTION ONTO GRANULAR ACTIVATED CARBON

ROSLAN BIN OMAR

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FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING
UNIVERSITY TUN HUSSEIN ONN MALAYSIA

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ABSTRACT

The kinetic theory of liquid indicates that diffusion coefficient for the dilute liquid at ordinary pressure is essentially independent of mixture composition. Mass transfer is important in separation and adsorption process. However, diffusion may also be caused by other features. Because of the complex nature of mass diffusion, the diffusion coefficients are usually determined experimentally. The mass transfer resistance controls the kinetic adsorption rate, but there is only limited understanding of the adsorption of a solute onto porous material from surface water. Thus, this study was conducted to further enhance the understanding of the mass transfer and adsorption processes of micropollutants. The objectives of this study are to analyze the difference, examine the adsoprtion diffusion of mass transfer and evaluate the variation of total, internal and external mass transfer. This study also used the transformed equation to analyze the rate of adsorption during adsorption process onto different GACs. Five (5) micropollutants namely Hg, Cd, As, DDT and chlordane have been chosen to be adsorbed onto three (3) granular activated carbon which are SIG (shell industrial grade), SAG (shell analytical grade) and BAG (bitumen analytical grade). The micropollutants (Hg, Cd, As, DDT and chlordane) were prepared using standard stock solution in deionized water. Adsorption of pollutants onto SIG, SAG, and BAG were started at different percentages of outflow. Although the samples were taken at the same time, the outcome showed that a significant competition between adsorbates and adsorbents. From the analysis, SIG and SAG displayed excellent performance in adsorbing inorganic micropollutants while BAG for organic micropollutants. Before adsorption takes place, the morphology of the SAG indicated pore abundance compared to SIG and BAG. BAG pores are more structured than SIG and SAG. After adsorption occurs, more of the organic micropollutants are being adsorbed onto BAG and SAG. Meanwhile, SIG proved to be the best adsorbent for inorganic micropollutants. It takes 72 hours for Hg

and As to saturate SIG whilst Cd take a longer time of 80 hours. SAG was also a good adsorbent for organic elements, with DDT taking 52 hours and chlordane taking 48 hours to be adsorbed. The $[K_La]_f$ value for the adsorption of Hg onto SIG was significant and the $[K_La]_d$ value for the adsorption of Hg onto SIG was higher onto SAG and BAG. The value of $[K_La]_f$ for SIG at 6% outflow was 0.6862 h^{-1}, with values of $[K_La]_d$ at -0.4142 h^{-1} and $[K_La]_g$ at 0.2721 h^{-1}, while for the adsorption of Cd it was shown that the $[K_La]_f$ values for the adsorption of Cd onto BAG was the most significant and the $[K_La]_d$ values for the adsorption of Cd onto SIG was higher than SAG and BAG at 2% outflow, with values of 0.7044 h^{-1}, $[K_La]_d$ at -0.3687 h^{-1}, and $[K_La]_g$ at 0.3356 h^{-1}. In contrast, for As the $[K_La]_f$ for the adsorption of As onto BAG at 4% outflow was 0.6722 h^{-1} and $[K_La]_g$ was 0.3103 h^{-1}. For DDT, the $[K_La]_f$ value of DDT for BAG at 0.5% outflow was 1.6662 h^{-1}, $[K_La]_d$ was -1.2702 h^{-1} and $[K_La]_g$ was 0.3959 h^{-1}. In the case of DDT, the value of $[K_La]_f$ for the adsorption of chlordane onto BAG at 2% outflow was 0.7330 h^{-1} and $[K_La]_d$ was started to activate the adsorption -0.5567 h^{-1}. $[K_La]_g$ at 2% outflow was 0.1763 h^{-1}. From these values we can conclude that for the adsorption of inorganic substances, SIG proved to be the best, while for organic substances BAG is the best adsorbent.

ABSTRAK

Teori kinetik cecair menunjukkan bahawa pekali resapan untuk cecair cair pada tekanan biasa pada dasarnya bebas daripada komposisi campuran. Pemindahan jisim adalah penting dalam proses pengasingan dan juga penting untuk proses penjerapan. Walau bagaimanapun, resapan boleh juga disebabkan oleh kesan-kesan lain. Oleh kerana sifat kompleks resapan jisim, pekali resapan biasanya ditentukan secara uji kaji. Rintangan pemindahan jisim berfungsi untuk mengawal kadar penjerapan kinetik, tetapi pemahaman tentang penjerapan bahan terlarut keatas bahan penjerap adalah sangat terhad. Kajian ini dijalankan untuk mendalami pemahaman proses pemindahan jisim dan penjerapan bahan pencemar mikro. Objektif kajian ini adalah untuk menganalisis perbezaan, mengkaji penyebaran penjerapan pemindahan jisim dan menilai perubahan total, dalaman dan luaran pemindahan jisim dengan menggunakan persamaan yang diubahsuai untuk menganalisis kadar penjerapan lima (5) pencemar iaitu Hg, Cd, As, DDT and klordan ke atas tiga (3) bahan penjerap iaitu SIG, SAG, BAG. Bahan pencemar Hg, Cd, As, DDT dan klordan disediakan dengan mengunakan cecair stok dari air suling. Penjerapan Hg, Cd, As, DDT dan klordan ke atas SIG, SAG, dan BAG bermula pada peratusan keluar air yang berbeza walaupun sampel tersebut diambil serentak. Hasil analisis menunjukkan persaingan yang signifikan antara penjerap dan perjerapan. Sebelum penjerapan berlaku, analisis morfologi menunjukkan lebih banyak liang pada SAG berbanding dengan SIG dan BAG. Setelah penjerapan berlaku, didapati pencemar organik lebih terjerap ke atas BAG dan SIG. Daripada analisa morfologi menunjukan BAG dan SIG telah menjadi lebih tepu. SIG juga didapati sebagai penjerap pencemaran mikro bukan organik terbaik dengan penjerapan Hg mengambil masa selama 72 jam, Cd 80 jam dan As 72 jam untuk sampai ke tahap tepu. Daripada analisis data, SAG dan BAG menunjukkan penjerapan yang baik untuk bahan pencemar organik,

dengan penjerapan DDT mengambil masa 52 jam dan klordan 48 jam. Nilai $[K_La]_f$ untuk penjerapan Hg ke SIG adalah ketara dan nilai $[K_La]_d$ untuk penjerapan Hg ke SIG adalah lebih tinggi daripada SAG dan BAG. Nilai $[K_La]_f$ untuk SIG pada 6% aliran keluar adalah 0.6862 h^{-1}, dengan nilai $[K_La]_d$ pada -0.4142 h^{-1} dan $[K_La]_g$ at 0.2721 h^{-1}, manakala bagi penjerapan Cd telah menunjukkan bahawa $[K_La]_f$ untuk penjerapan Cd ke BAG adalah yang paling ketara dan $[K_La]_d$ untuk penjerapan Cd ke SIG adalah lebih tinggi daripada SAG dan BAG pada 2% aliran keluar, dengan nilai 0.7044 h^{-1}, $[K_La]_d$ -0.3687 h^{-1} dan $[K_La]_g$ 0.3356 h^{-1}. Sebaliknya, untuk As $[K_La]_f$ penjerapan untuk As ke BAG at 4% aliran keluar ialah 0.6722 h^{-1}, $[KLa]_d$ adalah -0.3669 h^{-1} dan $[K_La]_g$ adalah 0.3103 h^{-1}. Untuk DDT, nilai $[K_La]_f$ DDT untuk BAG pada 0.5% aliran keluar adalah 1.6662 h^{-1}, $[K_La]_d$ adalah -1.2702 h^{-1} dan $[K_La]_g$ adalah 0.3959 h^{-1}. Dalam kes DDT, nilai $[K_La]_f$ untuk penjerapan klordan keatas BAG pada 2% aliran keluar adalah 0.7330 h^{-1} and $[K_La]_d$ telah mengaktifkan penjerapan di -0.5567 h^{-1}. $[K_La]_g$ pada 2% aliran keluar adalah 0.1763 h^{-1}. Dari nilai-nilai yang diperolehi, kita boleh menyimpulkan bahawa bagi penjerapan bahan-bahan bukan organik, SIG membuktikan sebagai penjerap yang terbaik, manakala BAG adalah penjerap terbaik bagi bahan-bahan organik.

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LIST OF SYMBOLS AND ABBREVIATION

B	- potential mass transfer index relating to driving force of mass transfer (*mg/g*)
a	- surface of interfacial liquid-solid (m^{-1})
q	- accumulative quantity of the solute adsorbed onto GAC (*mg/g*)
t	- accumulation time (*h*)
β	- adsorbate-adsorbent affinity parameter (*mg/g*)
C_o	- concentration of the adsorbate to entry to the column (*mg/L*)
C_s	- concentration of the adsorbate to depart from the column (*mg/L*)
mg/L	- milligram per litre
µg/L	- microgram per litre
ng/L	- nanogram per litre
µm	- Micrometre
K_L	- mass transfer coefficient (*m/h*)
$[K_La]_d$	- porous diffusion factor or internal mass transfer factor (h^{-1})
$[K_La]_f$	- film mass transfer factor or external mass transfer factor, or volumetric film mass transfer coefficient (h^{-1})
$[K_La]_g$	- global mass transfer factor (h^{-1})
As	- Arsenic
As (III)	- Arsenic (III)
BHC	- beta-Hexachlorocyclohexane
CaCl	- Calcium chloride
$CaSO_4$	- Calcium sulphate
CC	- Cis-chlordane

Cd	- Cadmium
$Cd(OH)_2$	- Cadmium hydroxide
COOH	- Phenol
DDD	- Dichlorodiphenyldichloroethane
DDE	- Dichlorodiphenylchloroethylene
DDT	- Dichlorodiphenyltrichloroethane
Fe (ɪɪɪ)	- Iron (ɪɪɪ)
H	- Hydrogen
HCB	- Hexachlorobenzene
Hg	- Mercury
K_2S	- Potassium sulphate
$KMnO_4$	- Potassium permanganate
MnO	- Manganese oxide
NH_2	- Amine
NaCL	- Hdroxyamine
NaOH	- Sodium hydroxide
O	- Oxygen
OH	- Hydroxyl
$SnCl_2$	- Stannous chloride
TC	- Trans-chlordane
MRLs	- Minimum Risk Level
FMBO	- Ferrite and Manganese Binary Oxide
CDR	- Column Dynamic Reactor
GAC	- Granular activated carbon
SAG	- Shell analytical grade
SIG	- Shell industrial grade
BAG	- Bitumen analytical grade
WTP	- Water Treatment Plant

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